Exploring the future of ecogenomics

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Summary

This thesis starts from the premise that, in order for science and technology to adequately address complex societal problems, a more responsive science system is needed in which a broad range of actors with different views, needs and ideas have a voice. It is widely believed that outcomes of traditional mono-disciplinary research do not do justice to the underlying social, political, economic, cultural and ethical aspects of the innovation context. In addition, the societal anxiety, which is often witnessed with respect to innovations, is enhanced by the rather 'rational' way decisions concerning science and technology are usually made and societal tensions are subsequently managed. Clearly, in order to realize a better societal embedding of science and technology and to be able to address complex societal problems, other ways to manage science and technology in society are needed. In this thesis, the focus is on one specific approach that has been proposed as a strategy to develop technologies with desired positive impacts and with few (or at least manageable) negative impacts: *constructive technology assessment* (CTA). CTA was developed as an approach to deal better with the impacts of science and technology development, by opening up the innovation process in an early phase through dialogue between actors involved and affected by the technology.

This thesis presents an empirical study of CTA on an emerging technology, producing evidence that allows for the further development of a theory of CTA. In the period 2004-2008 a CTA process on ecological genomics (ecogenomics) we designed, implemented and evaluated. The CTA process aimed to facilitate broad societal reflection and to guide research activities into societal desirable directions. In thesis we present this process and its results, and reflect on how we addressed the challenges that were faced. As such, the thesis aims to contribute to the further development of the conceptual and methodological framework for CTA. In addition, with the implementation of the CTA approach within the Ecogenomics Consortium, the research aimed to contribute to the societal

embedding of ecogenomics.

Managing emerging science and technology in society

Technology Assessment (TA) originated in the 1960s as an approach that aimed to address the concerns about negative effects of science and technology. Although the aim of TA was to provide early warning and offer a perspective on future impacts of technology, it primarily served as after-the-fact gatekeeper and had not been able to bridge between promotion (optimize benefits) versus control (minimize negative effects) of new science and technology. CTA was proposed as a way to overcome the so-called control and entrenchment dilemma. In an early phase of technology development many options are still open for exploration and there are good possibilities for steering. There are, however, uncertainties about the positive and negative societal effects the technology will bring about in the future and societal attention is rather weak. In later phases of technology development, this situation is reversed. Positive and negative aspects are apparent, but the possibilities for steering are limited.

A central assumption underlying the approach is that, if proponents and opponents jointly discuss technologies in an early phase, this results in a shared responsibility for the design process, the technology and its effects. There is a strong emphasis on involving both users, producers and parties affected by the technology, and facilitate them to interact. In literature on CTA, anticipation (whether and how participants take long term effects into account), reflexivity (reassessment of participants own actions, which can be triggered by interacting with others), and societal learning (new understanding that can be either factual or about the underlying dynamics of technological development and innovation processes) have been identified as quality criteria for developing CTA processes. Although the theory on CTA clarifies the way in which science and society are intertwined, and emphasizes the need for early integration, the ideas on CTA remained largely programmatic over the past years.

Within the literature, four central challenges can be identified that need to be addressed when designing, implementing and evaluating a CTA process. First, concrete technologies are absent, which implies that an impact assessment is speculative. Therefore, when CTA addresses technologies in their early phases of development, visions of the future are necessary in order to stimulate learning about possible impacts and to orient future actions. Reflecting on ways to look at future developments is thus a crucial part of CTA processes. Second, CTA

processes require reflexivity of and between participants. A related challenge for CTA processes is how to facilitate deliberation between participants. Shaping CTA processes as deliberative processes implies a need for participatory methodologies that create room for the analysis of positions of different actors, increase their reflexivity, and facilitate learning processes between them. Furthermore, in-depth analysis of the learning that takes place during CTA processes is needed in order to gain insight in the micro-level learning processes that eventually determine the effectiveness of a CTA exercise. The third challenge concerns the need for CTA to become institutionalized. Institutionalization of CTA refers to a future in which CTA is becoming a regular part of societal practices, and where researchers and those likely to be affected by the technology are in the position to negotiate. As such, it refers to a larger process of change that implies shifting roles of actors on different levels. As a fourth challenge, there is a need to further develop quality criteria for CTA. This is crucial to gain insight into the inherent and contextual conditions that determine the effectiveness of CTA exercises, and to subsequently improve CTA practices.

Research design

For the present study, we formulated the following main research question:

How can the conceptual and methodological framework for CTA be further specified, and how can a CTA approach be designed and implemented so as to effectively improve the societal embedding of emerging technologies in the field of ecogenomics?

In providing an answer to this question, we reflect on the choices we made in designing the CTA process on ecogenomics, and their consequences for the process and its results. As such, the research contributes to gaining more structural insight in the inherent and contextual conditions that determine the effectiveness of CTA exercises. The main question can be divided in three research questions, which determine the outline of this study:

I. How can CTA approaches be tailored to the context of emerging technologies?
II. What procedures can be followed to involve societal actors in, and integrate their knowledge into, innovation processes on ecogenomics?
III. What are the impacts of the CTA process and how can the impacts on the science and technology development process be increased?

The research presented in this thesis can be considered a social experiment which comprises the design, implementation and evaluation of a newly developed CTA process within the context of the Dutch Ecogenomics Consortium. As a starting point for designing the methodological approach, we used the *Interactive Learning and Action* (ILA) approach. The reason for choosing this approach as a starting point is twofold: (1) the approach has been extensively elaborated on and has been tested in practice in several contexts, and (2) we wanted to test its applicability to the context of emerging technologies. The phases of the ILA approach guided the research, while at the same time leaving room for an emergent design: experiences along the way shaped the CTA process on ecogenomics toward its final form. The chapters in this thesis present the subsequent steps in the CTA process.

Guiding visions in ecogenomics

In chapter 4, the first two phases of the CTA process are presented. The CTA process on ecogenomics aimed to involve societal actors in an early phase of science and technology developments. This early involvement is, however, challenged by the absence of concrete applications on which these actors can reflect from their own perspectives, and societal actors stressed a need for concrete images to reflect upon. In this chapter, different perspectives that can be distinguished from which to assess the future are described: probable, possible and desirable. As the ILA approach has a strong focus toward developing technologies into societal desirable directions, we focused on exploring desirable futures for ecogenomics and integrated the CTA approach with vision assessment. Ecogenomics researchers hold the most explicit visions. Their ideas about a desirable future for ecogenomics guided the research. Therefore, identifying their guiding visions was the starting point in the CTA process. Through literature study, interviews and focus groups, the guiding visions of ecogenomics researchers were identified. In particular during the interviews and focus groups ecogenomics researchers articulated a range of future ecogenomics applications in the fields of agriculture, soil pollution, nature conservation/development and environmental quality. In addition to the technical aspects of these applications, they reflected on contextual aspects, i.e. how, by whom, and why these applications will be used in the future. In particular the focus groups proved a valuable methodology in uncovering their ideas about contextual aspects. The results of the first phase shed light on the types of technologies that can be expected, who potential future users might be, and the important role of policies and practices. As such, it

provided crucial information for the next phases of the research, in which societal actors were challenged to reflect on desirable futures for ecogenomics.

Involving potential future users

In the third phase of the CTA process, potential future users reflected on ecogenomics and articulated ideas about desirable future developments. This phase is presented in chapter 5. Potential future users were chosen as participants in this phase based on their practical experiences and needs in fields related to ecogenomics developments. They were selected starting from the guiding visions articulated by the ecogenomics researchers in the previous phase. In some cases, the societal groups mentioned by ecogenomics researchers needed further specification. In addition, less evident groups that were not mentioned in the previous phase were also taken into consideration in selecting participants for this phase. Nine focus groups with homogeneous groups of potential future users were organized (69 participants in total). These groups comprised farmers, people from agricultural laboratories, people from large and small soil companies, people from environmental laboratories, civil servants, nature conservators and hobbyist gardeners. Although the visions of the ecogenomics researchers provided important input for the user groups to reflect upon, they were not taken as a starting point for the focus group discussion. To prevent prior framing, the discussions started with the current practices of the participants, and their needs and desires regarding soil use. Subsequently, ecogenomics was introduced and reflected upon from this perspective. In analyzing the results we identified the different ways of framing ecogenomics developments of the different participant groups. This illustrated how some application area's are closer connected to ecogenomics developments that others. For example, reflections of participants from the field of soil pollution were largely in line with the ideas of ecogenomics researchers about desirable future developments. In contrast, within the field of agriculture appeared to be not a widely experienced need for more attention to soil life; positive soil functions receive particularly little attention. Also language differences became apparent, i.e. nature conservators stressed that in order to think about how ecogenomics could be useful for their field, there is a need to develop a shared language. This phase exposed different ways in which ecogenomics developments could be relevant for different fields of application, and provided input for designing the next phase of the CTA process. In addition, a broad range of potential future users were facilitated to become acquainted with ecogenomics and reflect on it from their practical experiences before entering a dialogue.

Learning in dialogues

In the fourth phase of the CTA process a dialogue was organized in which ecogenomics researchers, users and policy-related participants jointly explored desirable futures for ecogenomics. This phase is presented in chapter 6. A particular challenge for such deliberative exercises within the framework of large public-private research consortia is to facilitate learning between participants, and to unravel the learning 'black box'. To this end we designed a dialogue methodology that aimed to identify matches between supply (ecogenomics research) and demand (user and policy practice), and related quick wins (short-term opportunities and actions). Two dialogue meetings were organized, one focused on 'Ecogenomics in agriculture and nature conservation', the other on 'Ecogenomics and soil pollution'. The analysis of the results focused on whether divergence and convergence between stakeholders on the ideas, problems, etc., and the assumptions underlying these demands occurred.

In both meetings, participants jointly succeeded in the identification and formulation of matches and quick wins (e.g. on ecogenomics and ecosystem services, and ecogenomics and the deep soil). In several cases, participants agreed on their relevance, indicated a need for follow-up initiatives, and in some cases they even made concrete appointments. On other matches and quick wins, there was less agreement, and participants indicated a need for further discussion. These observations illustrate the two functions of identifying matches and quick wins as a central methodological step in the dialogues. First, it leads to the joint identification of innovative opportunities for ecogenomics, and serves as a step in research agenda setting. Second, the matches and quick wins illustrate the creative potential of the participants when joining their knowledge, ideas and perspectives. Interestingly, there seemed to be little room for manoeuvre in the positions of policy-related participants. In contrast to users and researchers, they mainly stuck to their initial ideas and did not seem susceptible to the ideas raised by other participants.

There are indications that learning facilitated during the dialogues had a longer-term effect on three levels: (1) the individual level of the ecogenomics researchers, (2) the programme level of the Ecogenomics Consortium, and (3) the cross-institutional level. Concrete topics that were discussed during the dialogues could be traced back in the thinking and acting of ecogenomics researchers, and in new ecogenomics initiatives and project proposals. At the same time, these longer-term effects only partly reflect the learning that took place during the

dialogue meetings. The limited number of follow-up initiatives, and the absence of effects on the research projects of the Ecogenomics Consortium, illustrates the difficulty of translating the learning that took place during the dialogue meetings into 'real-time' actions. Clearly there are barriers that hamper translation of the results beyond the protected space of a dialogue. When stepping out of the dialogue setting into the real world, other dynamics, i.e. those related to traditional power relationships and institutional and funding structures, come into play which change the way dialogue outcomes are perceived and acted upon

Toward new governance structures

The research presented in this thesis shows that there is a discrepancy between the reflective learning that takes place within the protected space of the CTA process, and the longer-term impacts of that learning. The change in practice and routines implied by a CTA process is neither easy nor straightforward, and it is difficult to create ideal conditions in advance. In order to understand which barriers impede the impacts of CTA processes, and how CTA processes can contribute to the development of a deliberative mode of science governance, we take a transition theory perspective in chapter 7. A transition can be defined as a gradual, continuous process of structural change within a societal (sub)system. In terms of transition theory, the increasing emphasis on societal relevance and the involvement of stakeholders, the space it creates for innovative governance structures, and the field of practitioners developing theories and methodologies within this space, can be considered as the development of a niche. Within this niche, CTA processes can be seen as transition experiments. These experiments are steps in a transition toward a social responsive science system, which would entail the more structural involvement of societal actors in decision-making processes on (emerging) science and technology developments. In order to realize such a transition, fundamental changes in the dominant structure (physical, institutional, and economic structures), culture (shared images, norms and values), and practices (routines, behaviour, ways of handling and implementation) are needed.

Taking a transition theory perspective proved to be helpful in understanding the dynamics surrounding the CTA process on ecogenomics, and points to the important role of evaluation and accountability mechanisms in the way researchers position themselves within deliberative processes. This implies that optimizing CTA processes in terms of anticipation, reflexivity and learning is crucial to guarantee an effective deliberative process, but is not enough to

ensure impacts on the science and technology development process. External incentives seem to be crucial in this respect. We argue that the demand for societal relevance and stakeholder interaction by funding agencies needs to go along with concrete guidance (how is societal relevance defined, and what are the demands regarding stakeholder interaction?), tools for evaluation (how will the effectiveness of interactive endeavours be judged?), and instruments that create room to actively explore social desirable directions for research (how is flexibility of research programmes ensured?). In the context of CTA, these aspects need to be addressed at the niche and regime level simultaneously. At a niche level, CTA processes need to experiment with incorporating a system perspective and creating willingness for change both with actors from the niche and regime level. At a regime level the dichotomy between demands for societal relevance and the involvement of stakeholders on the one hand, and the lack of supporting incentive systems and accountability mechanisms on the other hand needs to be addressed.

Main conclusions

Overall it can be concluded that a carefully designed CTA process, which takes into account a range of quality criteria concerning both process and outcome, can successfully facilitate reflective learning between a range of societal actors. In summary, the following main conclusions can be drawn:

- The research presented in this thesis further specified a methodology for CTA by developing and testing methodological guidelines. For example, integrating CTA with vision assessment proved to be useful for opening up a discussion on emerging technologies, and involving actors without any prior knowledge about the technological developments in a meaningful way. The research also defined quality criteria for designing, implementing and evaluating CTA processes. As such, the research offers a contribution to the scientific body of knowledge on CTA.
- The results of the CTA process shows a balanced representation in terms of issues of promotion and control. Desirable future directions for ecogenomics have been identified, while at the same time related concerns have been addressed within the process.
- Given the difficulties of the researchers in the Ecogenomics Consortium in overcoming the boundaries of their separate disciplines and functioning as an interdisciplinary field, it is remarkable that during the CTA process researchers succeeded at generating an interesting and interdisciplinary

visions on opportunities for ecogenomics from the perspective of societal relevance. This shows the strength of these types of deliberative processes in bridging between disciplines and societal domains.

- Nevertheless, the impact of the CTA process on the science and technology developments in the field of ecogenomics remained modest. In particular the context of the research system in which the Ecogenomics Consortium was functioning appeared to have a large effect on the extent to which researchers were willing and able to integrate the results in their daily work.
- For the further development of the conceptual and methodological framework for CTA, we would suggest that incorporating a 'system perspective' and addressing the niche-regime interaction offers opportunities to increase the impacts and actually shape emerging science and technology that address societal needs.